PB84-110030

Controlling the Epidemic of Hazardous Chemicals and Wastes

(U.S.) Municipal Environmental Research Lab.
Cincinnati, OH

1983

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. PB84-110030
EPA-600/J-83-067		

4. TITLE AND SUBTITLE
CONTROLLING THE EPIDEMIC OF HAZARDOUS CHEMICALS AND WASTES (Journal Version)

5. REPORT DATE
1983

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Ronald D. Hill

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Municipal Environmental Research Laboratory
Solid and Hazardous Waste Research Division
26 W. St. Clair Street
Cincinnati, Ohio 45268

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
Municipal Environmental Research Laboratory--Cin.,OH
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

13. TYPE OF REPORT AND PERIOD COVERED

14. SPONSORING AGENCY CODE
EPA/600/14

15. SUPPLEMENTARY NOTES
REF: Ambio 12(2):86-90 (1983)

16. ABSTRACT

The disposal of waste products by man has led to the contamination of soil and groundwater. Problems associated with the disposal of hazardous waste are of major concern. Using the U.S. Environmental Protection Agency's definition of hazardous waste, the contamination of soils and groundwater resulting from waste disposal is viewed from two standpoints: (1) disposal of waste so that contamination does not occur; and (2) problems and solutions to situations where the soil or groundwater has already been contaminated. Six approaches to safe disposal are considered: (1) secure hazardous waste landfills; (2) co-disposal of hazardous and municipal waste; (3) land spreading; (4) deep-well disposal; (5) underground mine waste; and (6) alternatives to land disposal. Options for decontaminating soil and groundwater are discussed, in case the research needs in the 1980's are identified.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
RELEASE TO PUBLIC	UNCLASSIFIED	6
	20. SECURITY CLASS (This page)	22. PRICE
	UNCLASSIFIED	

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

EPA-600/J-83-067
JOURNAL ARTICLE

Controlling the Epidemic of Hazardous Chemicals and Wastes

BY RONALD D HILL

The total amount of hazardous waste produced each year is unknown. But in the US alone the EPA has identified 1000–2000 waste disposal sites that may pose a threat to human health and the environment. Photo: Mackwitz.

Hazardous wastes are almost exclusively by-products of industrial processes, and the problem of their safe disposal is thus primarily—but not exclusively—a problem for the industrialized and industrializing nations. There are notable exceptions to that statement. Some developing countries have been approached to serve as dumping sites for wastes too noxious or too expensive to be disposed of in the industrialized nations which produced them; and there is growing and justified concern about chemical contamination of the environment in the Third World through over-zealous application of agricultural chemicals—including some deemed too dangerous to be used in the countries where they are manufactured. But in the main, hazardous wastes are produced in the industrialized nations and ultimately must be disposed of by them.

The total amount of hazardous waste produced each year is unknown, in part because much depends on the definition of "harzardous." US Environmental Protection Agency regulations and the US Resource Conservation and Recovery Act establishes a fairly broad definition. Waste is hazardous which... "because of its quantity, concentration or physical, chemical or infectious characteristics may:
(a) cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or
(b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed (1)." The EPA augments that definition by establishing criteria for the ignitability, corrosivity, and reactivity of wastes, and by designating as hazardous, wastes from certain sources—specific industrial processes, for example—or those which contain certain substances. Given that fairly broad definition, the EPA estimated that in 1979 between 10 and 15 per-

AMBIO VOL. 12 NO. 2
pp. 86-90
(1983)

cent of all industrial waste in the US—or 35 to 50 million tons (wet) each year—should be deemed hazardous. That does not include hazardous wastes from non-manufacturing sources, such things as waste oil from filling stations, ash from power plants, dredged materials, and contaminated debris, mostly due to oil spills. Thus while there is no overall estimate of the total global production of hazardous wastes, obviously the problem of their disposal is a substantial one.

In fact it is two problems: providing adequate methods of dealing with the wastes which are continuously produced, day by day, from the world's industrial processes; and remedying the damage to the environment (and human health) caused by improper disposal of wastes in the past.

The principal hazard of improper waste disposal is contamination of soil and groundwater, particularly the latter. In the US, as in most other industrialized nations, the most common—and most troublesome—method of waste disposal is landfilling, a euphemism for land dumping in one form or another. By one estimate (2) the US landfills 90 percent of its hazardous wastes. As a consequence over 10 000 hazardous waste dump sites have been identified in the US; of these, 1000–2000 may be a threat to the public and the environment (3). In addition, liquid wastes are frequently held in surface impoundments. According to one unpublished study prepared by the EPA (and reported in the *International Herald Tribune* Dec 30, 1982) there are more than 180 000 surface impoundments on 80 262 sites in the US; 90 percent of these are said to pose an actual or potential threat of groundwater contamination. This problem is not limited to the US, and in fact evidence of groundwater contamination can be found in all industrial societies (4).

A number of factors make the management of hazardous wastes complicated and expensive. The substances themselves are noxious and in some cases deadly, and that, combined with horrifying tales of past mismanagement of dump sites, has made it extremely difficult to overcome local opposition to the establishment of new disposal sites, which are urgently required in many countries. Many of the wastes are essentially non-degradable, and control of the sites must therefore be more-or-less permanent, which adds further to the costs. Contaminating wastes can reach the surrounding environment by a number of means—by surface run-off, by leaching into the groundwater, by direct contamination of soil—which makes the design and management of disposal sites more difficult and, again, more expensive. Finally the high cost of safe disposal tempts unscrupulous producers to cut corners, and unscrupulous disposal agents to opt for "midnight dumping." For example, in the northeastern US, where legitimate disposal costs exceed $100 per ton, Mafia-connected disposal companies have handled toxic liquid wastes by the simple expedient of filling a tanker truck with them, opening the discharge valve, and driving around the countryside until all the liquid had leaked away. Consequently, monitoring the production of hazardous waste and surveillance of its ultimate disposition have become significant additions to the total cost of disposal. The EPA has calculated that "administrative costs" account for about one-third of the total cost of hazardous waste disposal.

In addition, relatively minor changes in technology may also affect the disposal of toxic wastes, for example by changing the solubility of substances in water treatment sludges. The "traditional" wastewater treatments, such as lime precipitation of metal plating waste, can produce a relatively stable, semi-solid sludge which is less subject to leaching from disposal sites than the relatively unstable, relatively soluble sludges sometimes produced by "advanced" methods of water treatment like reverse osmosis.

Changes in the form in which waste is dumped can also alter its impact on the environment. The first stage in groundwater contamination is the development of a leachate—a collected liquid which is either a mixture of noxious substances or which has some such substances in solution. The production of leachate can be minimized by disposing of wastes in solid or semi-solid form—for example, by mixing liquids with absorbent material. The amount of leachate can also be reduced by ensuring proper drainage around waste disposal sites, so the amount of surface runoff entering the site is minimized.

Most toxic waste is still disposed of in landfills, many of which lack proper controls to prevent the poisons from contaminating the environment, especially the groundwater reservoirs. Cartoon: T Newlin.

MANAGEMENT OPTIONS

A fundamental principle of good waste management is that disposal should be regarded as a last resort, to be used when all practical efforts have been made to reduce, re-cycle, or recover waste materials. It is clear that disposal costs will continue to increase, and this should provoke increasing interest in reducing the amount of waste produced. In addition, relatively high prices for raw materials should increase interest in materials reclamation.

In the long run, it is reasonable to suppose that industrial production methods will become less waste-producing. Some shifts in production methods have already occurred—for example, cutbacks in the use of water as a means of reducing the volume of waste. But the level of waste-reduction-at-source to be expected from existing plants is limited; most of the easy reductions—using less water, for example—have already been made. Similarly, the immediate impact of re-cycling is not likely to be very great; most of the really "good" wastes are already being reclaimed. Despite the hope these options may offer for the future, the immediate problem remains one of disposing of vast and growing quantities of waste in ways that do not imperil human health or the environment.

Six approaches to safe disposal will be considered here: secure hazardous landfills; codisposal of hazardous and municipal waste; land spreading or treatment; deepwell disposal; underground mine storage; and alternatives to land disposal.

Landfill

A secure landfill can be defined as one which prevents any migration of waste or leachate out of the landfill to adjacent subsurface soil, as groundwater or surface water. Research has been conducted on the design, construction, and operation of secure landfills (5, 6). The US EPA has recently proposed regulations on the design, operation, and closure of landfills (7). Although research has been carried on in this area for several years, there are still areas that require further investigation. Some of these are:

1. How secure will landfills be following closure? For example, what is the life of a membrane system, landfill cover, and leachate collection system?
2. Ways to minimize leachate generation, and control the leachates once they are produced.
3. Selection of liner materials—for example, compatibility of liner materials and hazardous waste.
4. Selection of suitable sites for waste disposal with regard to geological, hydrogeological and other criteria.
5. Application of soil attenuation and dispersion principles to post-closure management of landfills.

Codisposal

Codisposal of hazardous waste and municipal waste is practiced in several countries, *eg* Great Britain and Canada (8). These countries feel that codisposal has the following attributes: the hazardous waste is absorbed and diluted by the municipal waste to the point that leachate quality and quantity are not adversely impacted: and a co-stabilization and treatment process takes place such that the hazardous waste is rendered stabilized along with the municipal waste. Research continues today in several countries on codisposal (5): however, several questions remain to be answered:

1. Which hazardous wastes can safely be codisposed?
2. What is the optimum hazardous waste/municipal waste ratio?
3. How should the landfill be operated to stimulate stabilization and treatment of the hazardous waste?

Land Spreading

Land spreading is commonly used for the disposal of domestic wastewater sludges, and for some hazardous waste. The processing of industrial wastes in municipal wastewater plants results in sludges with concentrations of some chemicals that may contaminate the soil. Heavy metals such as cadmium and mercury are primary examples. To protect the soil, particularly soil used to grow food chain crops, limits have been set on the total amount of cadmium in the sludge that may be applied to the soil, the annual application rate, and the sludge pH (7).

Land treatment of organic hazardous waste has been practiced by some industries, for example oil refineries (9), which involves the use of the soil surface as a treatment medium. Areas that are used for land treatment should be designed, managed, and ultimately closed so that ideally no restrictions need to be placed on the use of the land following closure, and so that ground and surface water pollution does not occur. Although land treatment has

Our Widening "Circle of Poison"

The hazardous by-products of industrial processes are a continuing international problem, but there is also increasing concern about more-or-less intentional toxification of the environment by chemical pollutants, especially agricultural chemicals. The Organization for Economic Cooperation and Development (OECD) has calculated that there are about 4 million known chemical entities, of which 70 000 are available commercially. Sales of chemicals by the 24 members of the OECD are estimated at $300 billion each year.

That volume of chemical use is obviously a matter of concern, particularly since most of the substances will eventually end up in the environment in one form or another. But one particular aspect of the international trade in chemicals has attracted unusual attention: the use in the Third World of agricultural chemicals deemed too dangerous to be used in the countries where they are manufactured. For example, it is estimated that the US produces $7 billion worth of pesticides each year and exports about 40 percent of that total; one-quarter of the exports are said to be products whose use is banned or restricted in the US.

Most industrialized nations have legislated rigid controls over the use of toxic chemicals at home. But some of them also export those chemicals to developing countries where such controls are usually non-existent. There is also a growing tendency for international chemical companies to open "formulation" plants in the Third World to evade restrictions on the manufacture of dangerous chemicals, or to avoid occupational health and safety regulations at home.

The developing nations are heavy users of agricultural chemicals. In Central America, for example, it is common to spray cotton crops 40 times or more each year, and pesticide use averages 3380 pounds per square mile annually. Tiny El Salvador, with a population of 4.5 million, accounts for fully 20 percent of the world's total production of parathion, a particularly dangerous organophosphate pesticide. Parathion use in El Salvador was said to average 2940 pounds per square mile in 1975.

There are a number of reasons for this intensive use of agricultural chemicals. Most of the pesticides and fertilizers used in the Third World—from 50 to 70 percent, according to the authors of *Circle of Poison*, the book which first disclosed the problem—are used on crops which are grown for *export* to the developed countries. Often those products are grown on large, single-crop plantations which are particularly susceptible to pests, but where the large-scale application of chemicals is easy. Since the produce is for export, extreme importance is attached to producing blemish-free products—the perfect banana. As much as 20 percent of the chemicals used may serve only to improve the appearance of fruit and vegetables for consumers in the industrialized nations. Finally, while the developing countries have benefited from increased production made possible by the hybrid plant species of the "Green Revolution," these hybrids are vulnerable to pests and disease, and require greater use of pesticides and fertilizers. Recently there has been a tendency for chemical manufacturers to take over seed companies, and to market seeds, pesticides and fertilizers as a package. This of course reduces the incentive to breed disease or pest resistant plant strains.

There are a number of unwelcome side-effects from this heavy use of chemicals. One is the development of chemical-resistant pests. In Central America, for example, there was only one important pest (the boll weevil) affecting the cotton crop before the heavy application of pesticides, and it was kept partially in check by natural parasites and predators. Now there are at least eight serious cotton pests in the area.

A second effect is the poisoning of workers and residents in the Third World. Workers are often not told about the hazards of the chemicals they use, and safeguards are frequently ignored or misunderstood—as, for example, the case of a Brazilian mother who applied a pesticide to her children's heads to free them of lice and fleas, and watched helplessly as they died. Agricultural workers commonly live beside the fields they work, they eat crops grown in the same area, and frequently their only sources of water are drainage ditches fed by run-off from heavily sprayed fields. Not surprisingly they get sick, and some die. The average rural worker in Central America carries about 11 times as much DDT in his tissues as the average American. And in 1977 the Central American Nutrition Institute found that the DDT levels in the milk of women living in the cotton-growing areas of Guatemala was the highest ever recorded in the western world.

The chemicals also contaminate the products they are meant to improve. The US General Accounting Office has found that "a large portion of the food imported into the United States may in fact contain unsafe pesticide residues." DDT levels of 106 ppm (compared with a US maximum recommended level

been used by some industries for a long time, the lack of systematic studies has limited the knowledge and data base with regard to important parameters and interactions. Research required in this area includes:

1. The establishment of those wastes which can be safely land treated.
2. A basic understanding of the interactions between soil and hazardous waste.
3. The development of management practices, *eg* loading rates, soil cultivation, nutrient requirement, and vegetation interaction.
4. The development of methods for closure of land treatment sites.

Deepwell Disposal

Deepwell disposal involves injection of liquid waste into subsurface porous formations isolated from potable water and mineral bearing strata. The material is intended to be permanently stored in these formations. This practice is used extensively by the petroleum industry to dispose of brines produced and separated from the oil. Since the 1950s there has been a steady increase in the use of wells for the disposal of other industrial waste (10). In general, deepwell disposal techniques can be used for most aqueous wastes except chlorinated hydrocarbons. In the United States, over 250 wells containing 150 different chemical compounds are now operating. In 1980 approximately 11 percent of the hazardous waste of the United States was disposed of in this manner (11). In 1977, over 100 research projects on deepwell disposal were identified in the United States and other countries. In spite of the research that has been conducted, additional research is required in the following areas:

- To determine reactions of a waste stream or a mixture of wastes introduced into reservoirs of unknown water and mineral composition, at highly varied temperatures and pressures;
- To determine microbiological reactions in deepwell reservoirs;

The increasing use of pesticides in developing countries is causing alarm as pests become more resistant requiring even heavier doses of poisons to control them. To make matters worse, developed countries export a number of pesticides that are restricted or banned in their own countries to the developing world, where they are used on crops that eventually end up on the tables of rich world citizens. Photo: Tiofoto.

of five ppm) have been found in cattle from Central America. Nearly half the coffee, 15 percent of beans, and 13 percent of peppers imported from Latin America to the US were found to contain chemical residues. The contamination of food is substantial enough that at various times imports from various Latin American countries have been banned by the US Department of Agriculture. Similar cases have been reported in other industrialized countries.

There may be a savage irony in the prospect of the nations that recklessly export hazardous chemicals now importing them in their food, but in the end, over-zealous use of agricultural chemicals may defeat its own purpose. It toxifies the environment and poisons the poor to make perfect bananas and unblemished tomatoes; and it may make perfect bananas and unblemished tomatoes worthless.

Bill Dampier

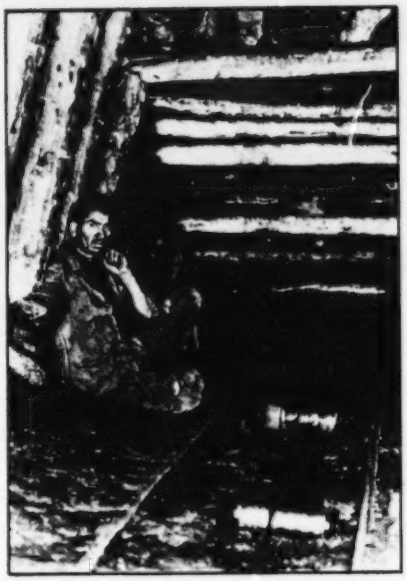
- Determining the effect of fluid injection on fault and joint planes, density stratification, fracture gradient pressure and permeability restoration;
- Developing monitoring methods to determine fluid movement within a reservoir, fluid escaping and its movement outside the original reservoir, and vertical fluid migration;
- Establishing conditions which result in plugging of the aquifer.

Underground Mine Storage

The storage of hazardous waste in deep underground mines is another disposal option. The solid waste is packaged, usually in drums or special containers, and stored in specially prepared rooms. Salt, potash, and gypsum deposits have the greatest potential for waste storage for the disposal of radioactive waste in mines (12, 13). Several studies in both the United States and Europe are underway as the storage of these types of wastes are connected with particular problems. An underground salt mine for the storage of hazardous waste is in operation in West Germany (14), which has proven to be a highly desirable way of disposing of hazardous waste. One advantage of this method is that material can be reclaimed at a later time if a use for it can be found. The US Environmental Protection Agency conducted a study of mine disposal and reviewed criteria for the selection, development, and operation of a mine system (17). Since this disposal option is highly site specific, the major investigative needs are related to the geologic and mine conditions at that particular site.

Alternatives to Land Disposal

One method of protecting the soil and groundwater from contamination is by alternative disposal methods. The two major options are incineration and treatment. When burned at the proper temperature for a sufficient period of time most organic hazardous waste can be destroyed or made harmless. Incineration is not applicable to some inorganic waste. Many hazardous wastes can be rendered non-hazardous through various treatment processes. Because of the demands on land resources in the European countries, incineration and treatment are more commonly utilized there than in North America (5). A significant trend in the European countries is to centralize hazardous waste facilities where treatment and incineration are the major disposal techniques. These practices do not normally lead to soil or groundwater contamination. However, there are some problems with heavy metals in the ash remaining after incineration. In addition other problems arise after incineration of wastes such as the accumulation of heavy metals in fumes resulting in uncontrolled atmospheric pollution.



Abandoned mines are being used to store highly contaminated wastes under controlled conditions. Photo: Earthscan.

PRIORITIES FOR THE 1980s

Most of the industrial nations of Europe and North America have recognized the significance of the problems of soil and groundwater pollution resulting from improper disposal of waste. These nations have made concentrated efforts to control the problem through laws and regulations and major advances have been made (4, 5).

In developing nations the consequences of poorly planned waste disposal practices often are not understood and in the developed nations those pushing industrial development at all costs often ignore the environmental problems.

The industrial nations have become concerned with disposal sites that have caused soil and groundwater problems (15). Several countries have taken steps to clean up these sites. The United States has passed a law authorizing a cleanup program in excess of one billion dollars (16).

There is now an urgent need for all nations to continue to share and exchange information on the latest state-of-the-art knowledge on waste disposal and soil and groundwater decontamination processes as well as the risks of polluting the atmosphere by incineration of wastes.

During the 1980s there are many research projects to be planned, performed and evaluated within the field of hazardous chemicals and wastes. In these projects ecotoxicological aspects must also be included (as well as aspects of occupational health problems for those working directly with the handling of wastes).

References and Notes

1. Environmental Protection Agency, *Hazardous Wastes and Consolidated Permit Regulations*. Federal Register, **45** No 98, pp 33066–33588, Washington, DC, May 19, 1980. Also US Resource Conservation and Recovery Act.
2. Geraghty and Miller, Inc, *The Prevalence of Subsurface Migrating Hazardous Chemical Substances at Selected Industrial Waste Land Disposal Sites*. Report Prepared for US Environmental Protection Agency, 1977. Available from US Department of Commerce, NTIS, PB 275–103, Washington, DC.
3. S Caldwell, K Barrett and S Chang, *Ranking System for Releases of Hazardous Substances*. In: Proceedings of Management of Uncontrolled Hazardous Waste Sites, pp 14–20, Hazardous Materials Control Research Institute, 9300 Columbia Boulevard, Silver Spring, MD (1981).
4. G L Singer. *The European Experience: Issues in Water Quality and Drinking Water Treatment*. Institute for European Environmental Policy, Bonn, Federal Republic of Germany (January 1982).
5. Committee on the Challenges of Modern Society, *Disposal of Hazardous Waste*, Report Number 122, North Atlantic Treaty Organization, Bonn, Federal Republic of Germany, April 1981.
6. N Schomaker, "Current Research on Land Disposal of Hazardous Waste," in *Land Disposal of Hazardous Waste*, Proceedings of the Eighth Annual Research Symposium, Publication EPA-600/9-82-002, pp 1–12, US Environmental Protection Agency, Cincinnati, OH, March 1982.
7. Environmental Protection Agency, "Hazardous Waste Management Systems," *Federal Register*, **47**, No 143, 32274 Washington, DC, July 26, 1982.
8. J Bentley, *Hazardous Waste Land Research*, Paper presented at International Hazardous Waste Symposium, Washington, DC, October 1981. Jack Bentley is associated with the United Kingdom Department of the Environment, London, England.
9. K W Brown and Associates, Inc, *Hazardous Waste Land Treatment*, Publication SW-874, US Environmental Protection Agency, Washington, DC, September 1980.
10. L R Reeder, *et al*, "Review and Assessment of Deep-Well Injection of Hazardous Waste," Publication EPA-600/2-77-029, 3 Volumes, US Environmental Protection Agency, Cincinnati, Ohio, June 1977.
11. *Hazardous Waste Generation and Commercial Hazardous Waste Management Capacity—An Assessment*. Publication SW-894, US Environmental Protection Agency, Washington, DC, (December 1980).
12. I Winograd. Radioactive Waste Disposal in Thick Unsaturated Zones. *Science*, **212** 4502, Washington, DC (June 1981).
13. "West German Salt Dome May be Used for Nuclear Waste," *Engineering and Mining Journal*, **183** 7, New York. (June 1982).
14. *Dienstleistungsbetrieb fur den Umweltschutz*. Kali und Salz AG, Kassel, West Germany (undated).
15. *Hazardous Waste Problem Sites—Report of an Expert Seminar*. Environment Committee Organization of Economic Cooperation and Development, Paris. (November 1981).
16. *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. Public Law 96-510, 96th Congress, Washington, DC. (December 1980).
17. R Stone, et al. *Evaluation of Hazardous Waste Emplacement in Mined Openings*. Publication EPA–600/2-75-040, US Environmental Protection Agency, Cincinnati, Ohio. (December 1975).

Mr Ronald Hill is Director of the Solid and Hazardous Waste Research Division of the US Environmental Protection Agency. His address: EPA, 26 West St Clair Street, Cincinnati, Ohio 45268, USA.